MEASUREMENTS AND MODELLING OF RADIO PROPAGATION IN SUBWAY TUNNELS

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INTRODUCTION

- Modern railway lines have 20 to 50% of tunnels.
- Radio communications in tunnels have high importance for ERTMS or CBTC.
- We proposed antenna solutions and repeaters for communications in tunnels with better performances and 1/10 cost reduction compared with leaky feeder.

OBJECTIVE

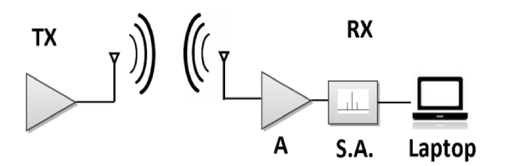
- Accurate modeling of propagation in railway tunnels is mandatory.
- Development of radio models from 900 to 5700 MHz in different types of tunnels.
- Development of antenna solutions for tunnels
- Test and measurements of narrow band (GSM-R) and Broadband (LTE) telecommunications systems.

METHOD

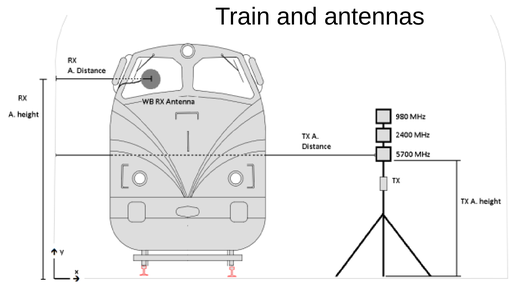
- Proprietary test and measurement system developed for this purpose.
- Measurements system composed of broadband transmitter, receiver and acquisition software.
- Base stations transmitting 980/2400/5700 MHz at same time, narrow and broadband.

Transmitter:

Receiver on board

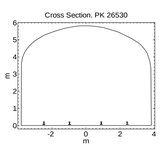


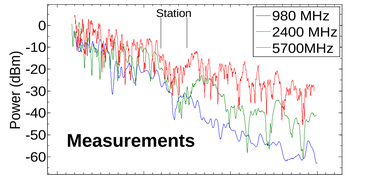
Train and antennas

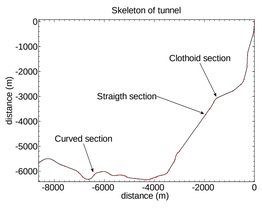


RESULTS

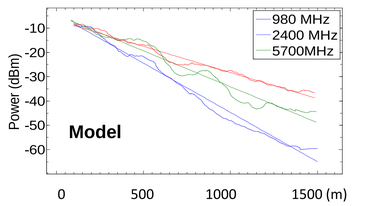
Straight tunnel





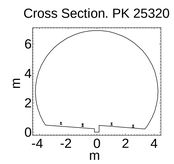


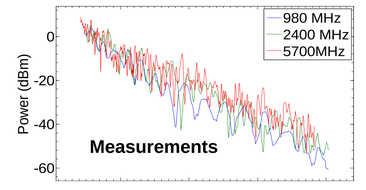
Received Power

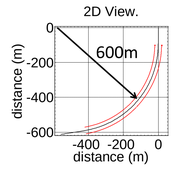


Frequency (GHz)	0.9	2.4	5.7
At (dB/100 m)	4.05	2.95	2.15

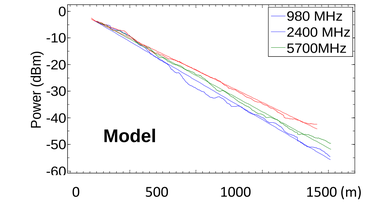
Curved tunnel







Received Power



Frequency (GHz)	0.9	2.4	5.7
At (dB/100 m)	7.33	6.82	6.05

DISCUSSION

- Accurate and high resolution measurements have been conducted at several common locations in Metro Madrid subway.
- Different types of tunnels and situations have been measured : straight/ curved/ tunnel to open area/ station / trains passing / broadband signals.
- Measurements have been precisely referenced to the environment to enable correction and improvement of the existing propagation model.

CONCLUSION

- Measurements have permit to develop and accurate propagation model for radio planning of antenna solutions in subway tunnels.
- It has been shown the higher attenuation rates in curves and places where changes in cross section or slope cause the blockage of the line of sigh.
- Some exceptions to well-known phenomena have been found in complex environments, like passing from open to tunnel or tunnels cross.